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FLIGHT TO A COMET

I. Yudin

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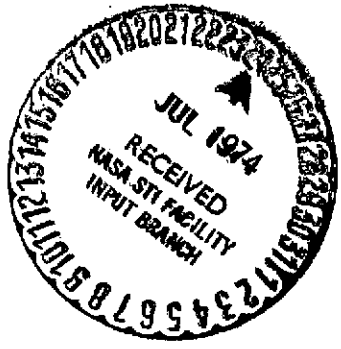

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16. Abstract

Certain puzzling problems of comets are discussed, as well as the possibilities of manned and unmanned space flights designed to solve these problems by direct observation and testing.

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FLIGHT TO A COMET

I. Yudin

Even in comparatively recent times, people have regarded the appearance in the heavens of stars with tails as good or evil omens. Remaining even today in many respects enigmatic, they hold the unwavering attention of scientists.

Our countryman, F. A. Brendikhin, became the founder of cometography. His successors--the Soviet scientists S. K. Vsekhsvyatskiy, O. V. Dobrovol'skiy, V. G. Riyves and others--engage fruitfully in research in this area. In the Ukraine, the first specialized cometary observatory in the world was recently created.

With the development of cosmonautics and the possibility of sending astronomical instruments out beyond the boundaries of the earth's atmosphere, the study of comets has risen to a qualitatively new level.

This year, cometic observations were conducted not only from ground stations and observatories, but also, for the first time, from artificial earth satellites and from aboard the orbital station "Skylab."

Plans are being elaborated for the direct investigation of comets with the aid of spacecraft. American scientists intend to launch the "Comet Explorer" in 1976--an unmanned craft for the study of Grigg-Skjellerup's comet from flight trajectory. Possibilities are being studied for launching a spacecraft which would approach Encke's comet in 1984 and would fly together with it over a certain period of time.

According to contemporary notions, comets have a solid base covered

with ices of various hydrocarbon compounds. The "cluster" of such compounds may vary for different comets and, in addition, may be contaminated with every admixture possible. This has its effect on the dimensions and shape of the tail.

Comets and meteors are closely related. Their obvious distinction consists in the fact that the former, in approaching the sun, throw out a huge trail of gas and dust, whereas the latter let their presence be known merely by burning up in the atmosphere of the earth.

In the movement and construction of comets there is still much that is vague. Scientists would like to have a more clear-cut idea of the nature of the interaction between a comet and the solar wind, of the mechanism of ion and free radical formation, owing to which the tail arises. It would be interesting to determine the composition of the comet's core. Scientists would also like very much to fathom certain peculiarities of these space wanderers, for example, the so-called non-gravitational effects.

In the motion of some comets, and above all, of short-period comets--i.e., those for which not more than 200 years pass between successive approaches to the sun (for long-period comets this cycle is more than 200 years)--phenomena have been discovered which cannot be explained by their attraction by known bodies of the solar system. Some such comets experience age-long accelerations while others, on the other hand, undergo decelerations. So far, no convincing explanation for these phenomena has been found. It is only conjectured that

they are the result of a reactive effect of flows of matter emanating from the core.

No less curious are other riddles of comets. Even if they are riddles. We know that each time comets return to the sun, they expend a significant portion of their matter on the formation of a tail. Therefore, their approximate life expectancy may be calculated. But comets appear again and again, displaying their finery as before.

Where then do they get matter for this process? Perhaps, during wanderings lasting many years in the gloom of space there occur in them changes incomprehensible to us? Or maybe the situation is simpler: are they transformed from long-period to short-period comets and unable to squander their entire substance?

It is not clear just where comets come from in the first place. If one suggests that they originated at the same time as the solar system, then they should have exhausted all their matter long ago. However, comets exist all the same, and their ranks are being constantly replenished. Astronomers estimate that the number of comets in the solar system amount to hundreds of billions. It is true that only a few of these, located within the orbit of Jupiter, are accessible to observation. Today, the orbital factors of nearly 600 comets have been computed.

What is to be concluded from this? Simply that comets are apparently being "made" somewhere. Where, in fact? There are two hypotheses. According to one they are the result of powerful volcanic eruptions on large

planets and their satellites. According to the other, they originate in the environs of the sun from a gigantic comet cloud formed during the formation of the large planets and now surrounding the solar system.

The growing interest in comets manifested by astronomers and astrophysicists is completely understandable: the study of these heavenly bodies will help to cast light not only on the problems specifically enumerated, but also on the origin of the solar system as a whole.

The comet Kohoutek, for whose study great forces were assembled at the beginning of this year in our own country as well as abroad, disappointed scientists somewhat: it turned out to be less bright than had been supposed. It appears that the brightness of these heavenly wanderers may increase in the degree that they approach the sun in accordance with various laws, but the attempt to determine in advance exactly which law applies does not always succeed.

In their initial prognoses, astronomers had certain grounds to suppose that the brightness of the comet Kohoutek would increase according to the maximum law, but it soon became clear that this was not the case. Nevertheless, the comet Kohoutek became one of the brightest of this century and the brightest of the last ten years.

The investigation of comets using spacecraft is an extremely interesting, though without doubt, complicated problem. Ye. V. Khrunov, pilot-cosmonaut of the USSR and Candidate of the Technical Sciences, tells of its peculiarities.

"Comets have different velocities in different phases of their orbits. The comet Kohoutek, for example, approached the sun with a velocity of more than 100 kilometers per second. Later, when it passed its perihelion -- the orbital point closest to the sun -- its velocity began to decrease. The farther a comet moves away from the sun, the more its velocity is reduced.

In what phase of the trajectory can there occur the approach of the spacecraft to the comet?

"In principle, in any trajectory that is accessible in terms of distance. But practically, the choice of a rendezvous or interception point will be determined by the goals of a planned scientific experiment.

"If, by way of illustration, it is limited to taking a sample of the gas and dust scattered in the tail of the comet, then it will suffice that the craft intersect the tail in any direction. The matter will be more complicated if we want the craft to approach the core of the comet, photograph it and conduct other research. In this case everything will depend on how long the craft must be stationed near the core. A flight close to it may turn out to be adequate. If this be the case, the staying time near the core of the comet will depend on the angle at which the craft intersects the comet's orbit.

"If we want the craft to be near the core of the comet for a more or less protracted period of time, it will be necessary for the craft to approach the object under investigation after the comet passes the perihelion. This is a most complicated task.

"Comets approach the sun from every direction. In order to approach a comet it is necessary to launch the craft into the comet's orbit or close to it, for it is not possible, at the present level of the development of cosmonautics, to change to any significant degree the plane of the craft's orbit: too much fuel would be required.

"Today, in launching any spacecraft, the rotation of the earth is taken into account, as a result of which the power of the carrier is, in effect, increased and a larger useful load can be carried aloft.

"When a craft is launched from the equator directly east, an increment of 465 meters per second is obtained. With a change in the angle of orbital inclination the increment diminishes. When the craft is launched into polar orbits the increase disappears and the rocket-carrier must be given the entire escape velocity.

"But what happens if we launch the craft against the rotation of the earth? Then, escape velocity plus 465 meters per second must be imparted to the craft.

"Consequently, in selecting comets for investigation, the potentialities of rocket and space technology must be given especially strict consideration.

"In sending a craft to a comet, the control requirements increase significantly. Since the core of a comet is a very small object in comparison with the moon and planets, it will be impossible to control the craft's flight from the earth, as is now done. This means that an automatic navigation system will be required.

"In all cases, the craft must be launched towards a predetermined point. But while the orbits of heavenly bodies like the planets are known with a sufficiently high degree of accuracy, still the orbit of a comet must be determined more precisely during the very flight of the craft and accordingly, corrections must be made in its trajectory; that is to say, a corrective maneuver must be performed. An inadequately precise knowledge of the comets orbit precludes the possibility of approaching its core.

"Some comets approach the sun much closer than did the comet Kohoutek, which approached to a distance of about twenty million kilometers. For the sake of comparison let us note that the earth revolves around the sun at a distance of about 150 million kilometers. One can imagine in what scorching heat a comet finds itself when it ventures to draw so near to the sun.

"In choosing a flight path to a comet for an unmanned craft, it would hardly be expedient to bring it close to the sun, for this would require powerful heat shielding for the protection of the craft.

"Such is the most general picture of the flight of an unmanned spacecraft to a comet."

The authors of science-fiction works do not limit themselves to unmanned devices. They dream of manned craft flying to comets and even suggest that the core of a comet be used for remote space voyages.

A specialist in the field of cosmonautics, Professor M. K.

Tikhonravov, spoke on the possibility of manned flights to comets.

"I know of plans for sending unmanned craft to comets to study at first hand the substance of a comet and its core. The reality of sending piloted craft to them also raises no doubts, though this is a much more complex problem than the former.

"Existing space vehicles are not adequate for this endeavor. Above all, their energy capability must be considerably increased; otherwise, it will be impossible either to overtake or to draw near to a comet.

"It goes without saying that such a vehicle must have available a reliable life-supporting system, since a flight--even if the vehicle remains near the comet's core for periods of short duration--may last rather long; after all, when the comet has been reached, you don't turn right around, but have to enter some new elliptical orbit which passes near the earth.

"Many factors would place restrictions on the flight of a manned craft, but what is especially important is the necessity of returning the crew to earth. All of the flight path computations and all of the maneuvers must be made and executed with these considerations in mind.

"In degree of compexity, sending a manned craft to a comet approximates the flight of a man to another planet, to Mars, let us say. But if we undertake this problem seriously, it is possible to solve it relatively quickly.

"For the present, of course, one may only speak of drawing near to a comet, taking samples of its matter, and photographing its core.

But that's all. Landing a spacecraft on a comet and flying on it beyond the boundaries of the solar system--these things, of which the visionaries write, must be left to our descendants."

Launching spacecraft to comets is yet another way of using the resources of cosmonautics for studying the history of the solar system.